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GENERAL DYNAMICS

Convair Division

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EVALUATION OF INCONEL X TO 301 STAINLESS STEEL RESISTANCE SPOTWELDS AT 78°F AND -423°F.

MRG-134

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GENERAL DYNAMICS/CONVAIR

TO: Distribution

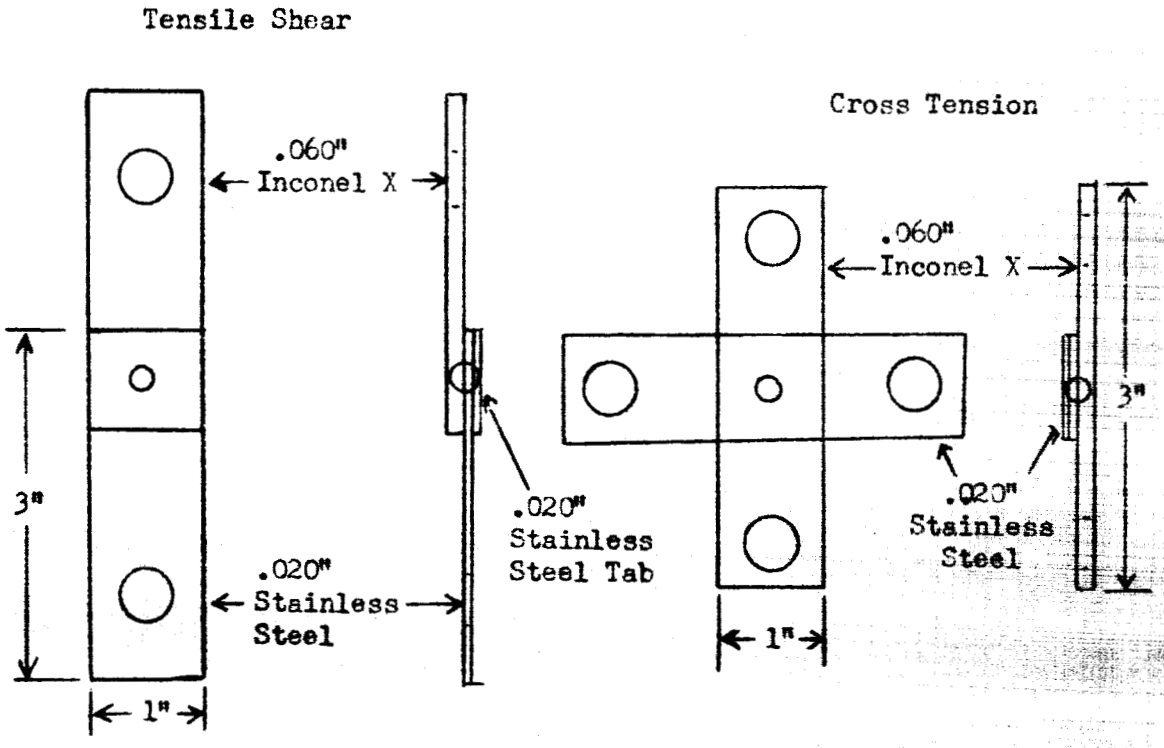
FROM: Materials Research Group, 595-2

SUBJECT: Evaluation of Inconel X to 301 Stainless Steel Resistance Spotwelds at 78°F and -423°F.

A significant reduction in the "dry" weight of present and future missiles and spacecraft could be made with the substitution of Inconel X (solution treated and aged) in place of annealed 321 stainless steel as a thrust ring material. The yield strength of aged Inconel X is approximately 90,000 psi compared to 30,000 psi for annealed 321, and both alloys have approximately similar densities. An Inconel X thrust ring could be produced by integral forming (ring rolling) or by butt welding and stress relieving followed by proper heat treatment (solution treated 2100°F/4 hr., aged 1550°F/24 hr. and 1300°F/20 hr. and air cooled). Furnaces capable of heat treating such rings with proper atmosphere control are commercially available.

However, the possible use of an Inconel X thrust ring would depend upon its welding characteristics and its cryogenic temperature properties when resistance spotwelded to the missile skin material, thin gauge (.010"-.020") highly cold rolled 301 stainless steel sheet. In order to ascertain the weldability and determine a welding schedule several samples of .060" Inconel X (solution treated and aged) were resistance spotwelded to .020" 301 stainless steel (0-71004) on a Taylor Winfield, 100 KVA capacity, machine. It was found that a .020" tab of stainless steel sheet was required on the 301 s.s. side (see sketch of specimens) to obtain a uniform and reliable weld. A welding schedule was determined and several cross-tension and tensile shear type specimens were made to determine the mechanical properties at room and subzero temperatures.

Specimen configurations were as follows:



A total of twenty cross-tension and tensile shear spotweld specimens have been tested at +78°F and -423°F (see data in Table 1). The tensile shear strengths of single spotwelds were well above the 500 pounds minimum requirement, and, as may be seen from the data tabulation, in all cases the Inconel X- stainless steel spotwelds were stronger than the stainless steel- stainless steel spotwelds. However, until further and more comparative data are accumulated, the most significant factor is that the tension/shear ratios for Inconel X- stainless steel spotwelds (081 at 78°F, and 0.24 at -423°F) were much superior to stainless steel-stainless steel spotwelds (0.77 at 78°F and 0.19 at -320°F).

It is also significant to ncte that the tensile/shear strength ratio for Inconel X- stainless steel spotwelds at -423°F is higher than that of the stainless steel-stainless steel spotwelds at -320°F. The latter represents a condition of use that has proved to be reliable and satisfactory in operation of the Atlas missile. It appears that, on the basis of these limited tests, Inconel X-stainless steel welds would perform satisfactorily at liquid hydrogen temperature.

Definite recommendations as to the use of Inconel X for thrust ring applications in present and future products cannot be made, however, without a considerable amount of additional data. The Materials Research Group has initiated a testing program to obtain the following mechanical property data on both annealed and age hardened Inconel X: F_{ty}, F_{tu}, e, E, and notched/unnotched tensile ratios at +78°F, -100°F, -320°F, and -423°F. In addition, further testing will be performed to determine the cross-tension and shear strength properties of .060" and .090" Inconel X and stainless steel spotwelded to thin gauge skin material. This testing will also be performed over a range of temperatures.

Based upon the limited testing performed to date, resistance spotweld joints between aged Inconel X and cold rolled Type 301 stainless steel appear to possess high strengths and reliable, reproducible properties at room temperature and at liquid hydrogen temperature. These promising results merit further consideration of Inconel X to reduce the weights of components such as thrust rings, flanges, and brackets.

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TABLE 1

SPOTWELD TENSION AND SHEAR TESTS

.060" Inconel X Welded to 0.020" Type 301 Stainless Steel, Spec 0-71004, with 0.020" Stainless Steel Tab over the Stainless Steel Sheet						.020" Type 301 Stainless Steel, Spec 0-71004 Welded to 0.020" Type 301 Stainless Steel					
Test Temp.	Cross-Tension Strength of Single Spotweld-lbs.		Tensile Shear Strength of Single Spotweld lbs.		Ratio Tensile/ Shear Strength	Test Temp.	Cross-Tension Strength of Single Spotweld-lbs.		Tensile Shear Strength of Single Spotweld lbs.		Ratio Tensile/ Shear Strength
+78°F		820		1115		+78°F		445		616	
+78°F		790		1090		+78°F		520		610	
+78°F		940		1050		+78°F		479		598	
+78°F		890		1080		+78°F		482		600	
+78°F		910		1050		+78°F		506		745	
	AVE.	870	AVE.	1077	0.81		AVE.	486	AVE.	634	0.77
-423°F		400		1600		-320°F		170		814	
-423°F		425		1685		-320°F		182		874	
-423°F		375		1495		-320°F		150		800	
-423°F		375		1670		-320°F		152		880	
-423°F		435		1865		-320°F		164		910	
	AVE.	402	AVE.	1663	0.24		AVE.	164	AVE.	856	0.19